Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project

TEAM:
Chevron Technology Ventures
Hyundai-Kia Motor Company
UTC Power

Linda Gallaher – Program Manager
Dan Casey – Technical Director
Chevron Hydrogen

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This presentation does not contain any proprietary or confidential information

TV-10

Overview

Timeline

- January 15, 2004
- September 30, 2009
- 30 % complete

Barriers

- Vehicles
- H2 Refueling Infrastructure
- Codes & Standards

Budget

- Total project funding - $93.9 mil
  - DOE share - $37.8 mil
  - Contractor share - $56.1 mil
- Prior Funding - $8.9 mil
- Funding FY06 - $4.9 mil

Team Members

- Hyundai-Kia Motor Companies
- UTC Power
- Hyundai Kia America Technical Center
- Alameda Contra Costa Transit
- Southern California Edison
- Tank Automotive Research, Development and Engineering Center (DOD)

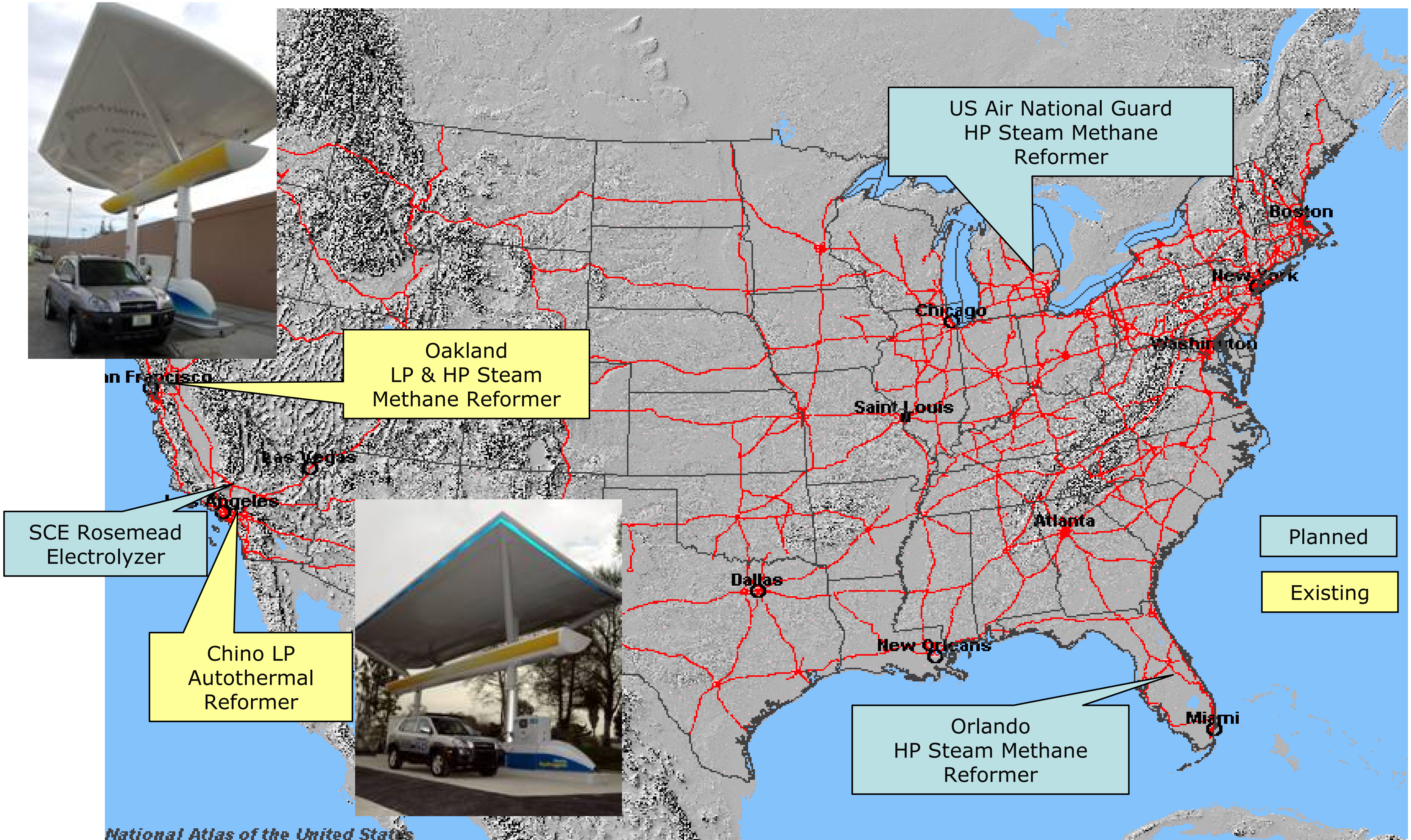
Objectives

Overall	Demonstrate different methods of on-site hydrogen generation Collect data on FC vehicle operation
2005	•Auto Thermal Reformer •Low pressure steam methane reformer (not funded by DOE) •Set up data collection and fleet monitoring system •Obtain data in hot and high altitude environments
2006	•Electrolyzer •Two high pressure steam methane reformers (not funded by DOE) •Test different climatic conditions on FC vehicles •Hydrogen safe chassis dyno facility

Approach

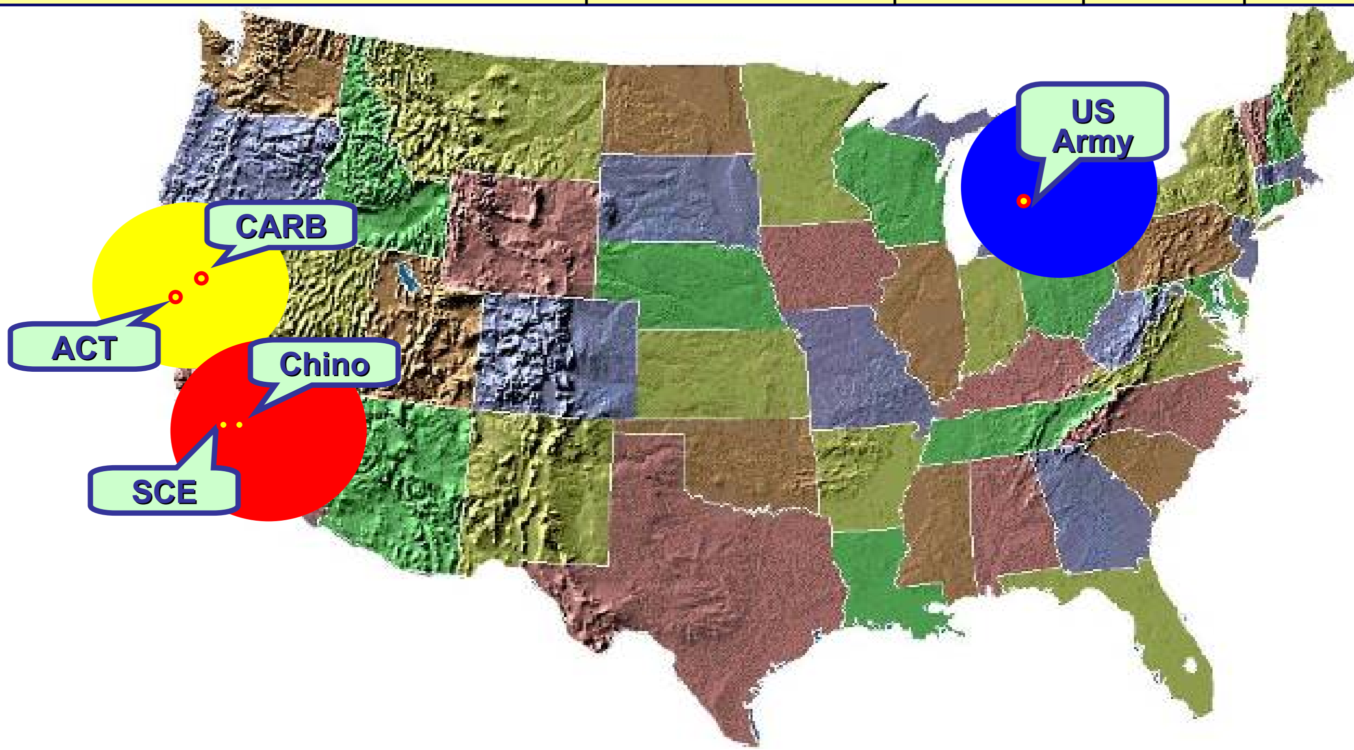
Infrastructure	Vehicles
Safe design and operations	Safety and Training
Multiple onsite generation methods	32 fuel cell vehicles
Varied geographic locations	Multiple Climate Conditions
CSA International 5.99 US certification for hydrogen generators	Cost reduction of key components
First Responder Training and community outreach	Increased reliability of fuel cell power train system and BOP

Approach - Infrastructure



Approach - Vehicle Deployment

Operation Area	Service Facility	Operator	Total	2005	2006	2007
Southern California	Chino	HATCI SC Edison	5 9	3 0	1 3	1 6
Northern California	Sacramento	CARB AC Transit	1 12	0 1	1 7	0 4
Michigan	Ann Arbor	US Army	5	0	2	3
3 Regional Area		5 Organizations	32	4	14	14



Infrastructure Progress/Results
Safe Design / Operations

- Process Hazards Analysis (PHA)
- Safety Objective Analysis (SOA)
- Factory Acceptance Testing
- Site Acceptance Testing
- CSA certification of generator
- Emergency Action Plan
- First Responder Training
- Operation and Maintenance Manuals
- Safe Work Practices (SWPs)
- Operator training

Vehicles - Progress/Results
Safe Operations

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- More than 20 employees have been trained in vehicle operation
- More than 5 people have been trained for maintenance and light repair of the vehicle
- HMC has provided an updated Emergency Response Diagram and Operating Manual
- AC Transit has provided First Responder training in Oakland
- HATCI in Chino has participated in First Responder Training organized by the CaFCP
- Safety presentation on the Tucson & Sportage FCV has been presented to NHTSA in March

Infrastructure - Chino Energy Station

- Auto Thermal Reforming
- 11 kg/day generation
- 110 kg storage
- Dual dispensers
- 5000 psig
- Fill rate – up to 1.2 kg/min

- Zero Safety Incidents
- 294 kg generated on site
- 134 fills
- 1400 cumulative hours on generator
- +99.994 % purity
- 48.3 % Primary Energy Efficiency

Infrastructure - Oakland Energy Station

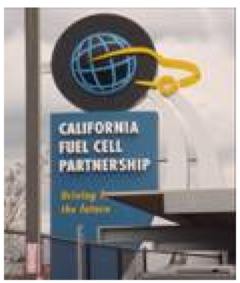
- Dual Steam Methane Reforming
- Total 150 kg/day generation capacity
- Low Pressure - 75 kg/day
  High Pressure - 75 kg/day
- 360 kg storage, Dual dispensers, 5000 psig
- Fill rate – up to 3 kg/min

- Zero Safety Incidents
- 860 kg generated on site
- 75 fills, 0.78 kg/min average
- 720 cumulative hours on generator
- +99.988 % purity product (111 ppm He)
- 63.1 % Primary Energy Efficiency

Vehicle Deployment Status

- Three vehicles at HATCI in Chino

- One vehicle at the CaFCP in West Sacramento



- Three vehicles at AC Transit in Oakland

Vehicle	Miles	Hours	Starts
V1	8,096	475	2,331
V2	6,230	409	1,576
V3	4,944	225	882
V4	2,571	126	442
V5	1,361	81	424
V6	924	39	217
V7	491	43	183
Total	24,617	1,398	6,055

Vehicle Technical Data

➢ Characteristics

- Operating Temp. : -20℃~ 40℃
- Life Cycle : longer than 1,500 hours
- High altitude drivability up to 14,000ft
- Identical Interior to ICE Tucson
- Less Noise, more Reliable and Easy to Operate

< Specifications >

Fuel Cell Stack Power	80 kW
Vehicle Weight	3,920 lb / 1,765 kg
Motor	~105 hp / 80 kW
Battery	Li-PB (144V, 6Ah)
Fuel Tank	Type III, 3-Tank 152 liters (3.5kgH2)
Fuel Efficiency	24km/gasoline liter eq. (~57 mpg)
Max. Speed	94 mph / 150 kph
Range	191 miles / 306 km
Emission	Water vapor only

Vehicle Testing

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- Wind Tunnel Test

- EMS Test

Vehicle Testing

- **Fuel Efficiency**
  - **Dyno baseline test conducted with V3 (DOE attending Dec. 12~14 @Quantum)**

Test Mode	Results
HWFET	64 mpg (Gas.)
UDDS	47 mpg (Gas.)

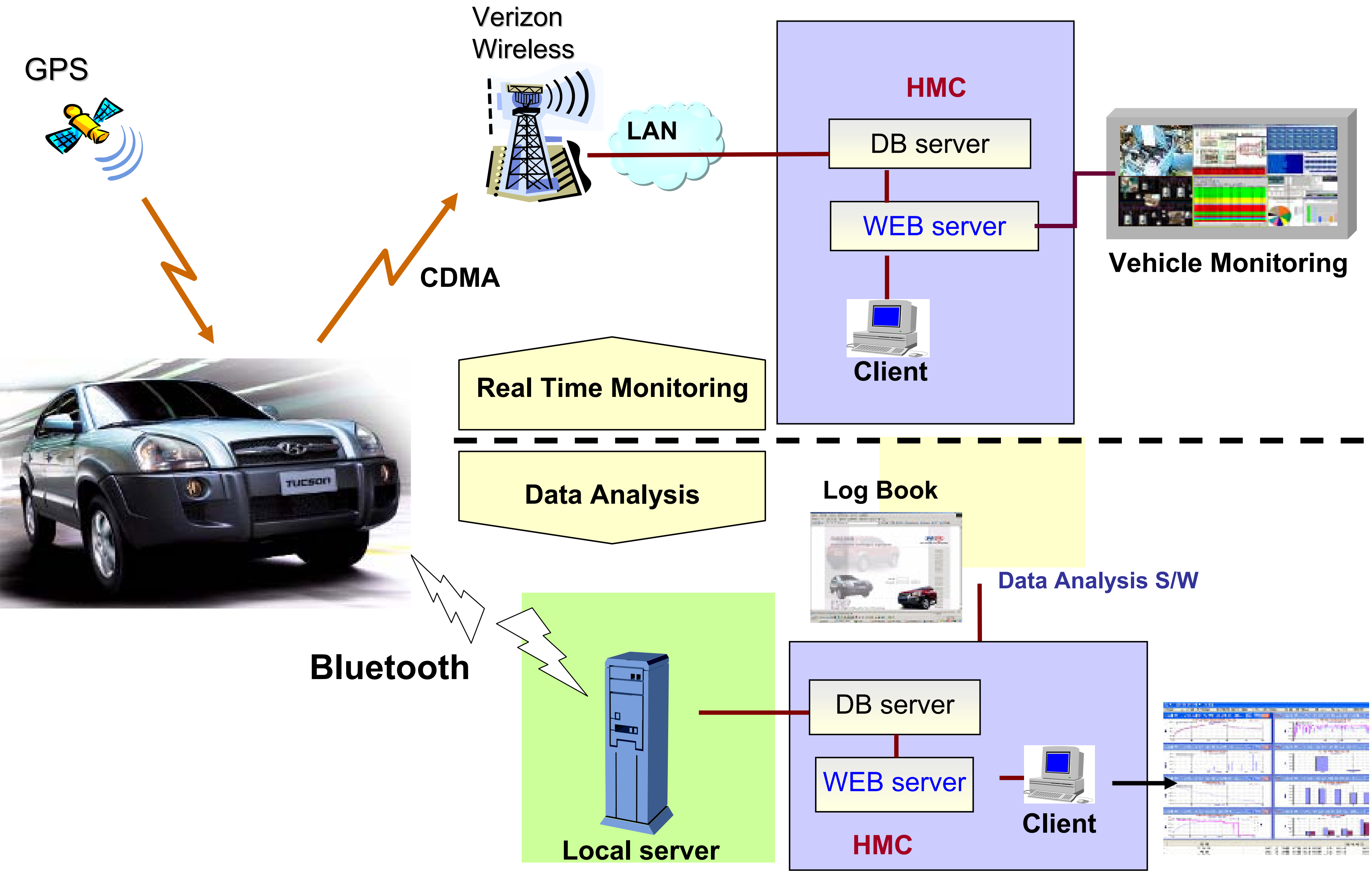
- **High Altitude Test**

October '05 @ Colorado (14,000 Ft)

- **Hot Test**

August '05 @ Death Valley (Over 100° F)

Fleet Monitoring and Data Collection



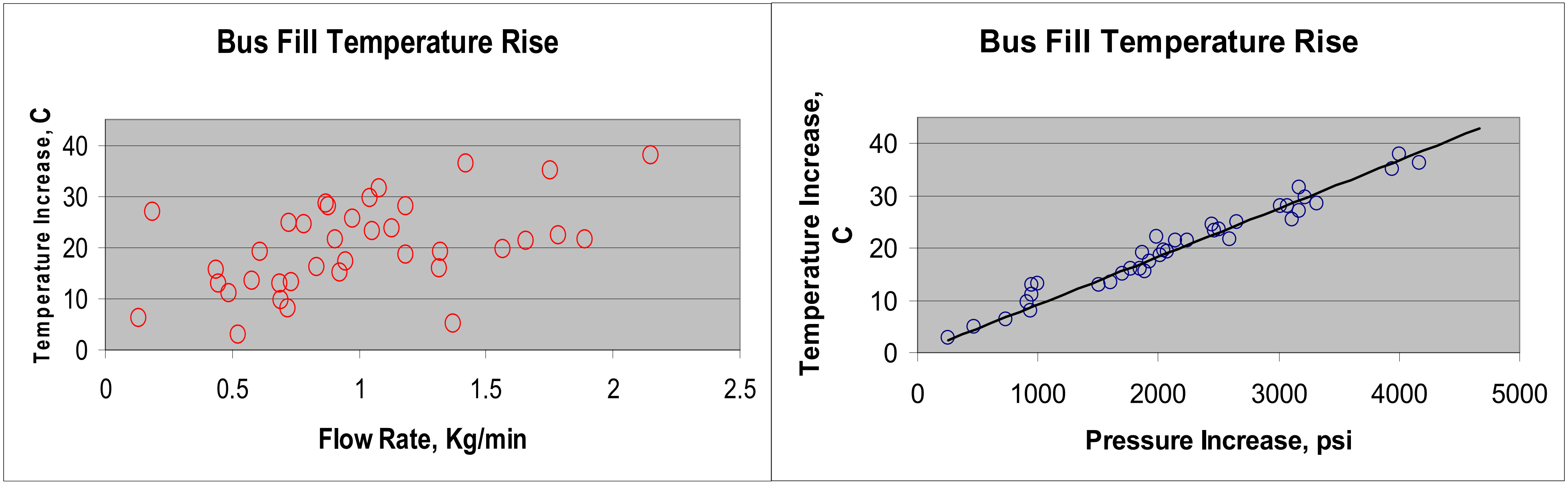
DOE Fleet Monitoring

- Purpose : - Prompt service through real time vehicle operating status monitoring
  - guarantees customer & vehicle safety through fleet monitoring
- Monitoring Items : vehicle location, vehicle data (speed, range, temp., fault code etc.)
- Monitoring Sites : USA (HATCI), KOREA (HMC)

Monitoring Room at HATCI

Monitoring Room at HMC

Technical Accomplishments
Bus Fill Temperature Effect



- Temperature increase is a function of:
  – Pressure increase not fill rate from 0.2 to 2.0 kg/min
  – Additional testing in progress

Future Work

- Start up Generators in:
  - Oakland, CA - High pressure SMR*
  - Rosemead, CA - Electrolyzer
  - Selfridge, MI - Advanced SMR
  - Orlando, FLA High pressure SMR*
- Hydrogen safe chassis dyno facility
- 18 Vehicles in operation by the end of 2006

*not in DOE program but data to be shared with DOE

Summary

- Two stations now on-line
  - both reformers CSA 5.99 US Certified
- Three additional stations will be on-line this year
- 7 vehicles currently deployed – Total 18 by end of 2006
- 76% of FCV Range Targets
- 25% of FCV Durability Targets
  - one vehicle now at 500 hours
- Next Year’s Challenges
  - Increased Range with 10,000 PSI/ 70 MPa
  - Increased generation efficiency

Response to Reviewers' Comments

- *Multiple climates identified, but not clear if vehicles will be left out in sub-zero weather for several days before startup.*
    - Yes, vehicles will be left outside in sub zero for multiple days before start up.
- *Project seems to be off to a slow start.*
    - Project is using on site generation vs. delivered hydrogen.
    - Generation technologies employed are new technology
- *Future plans are going in the right direction, but they seem to be uncertain about many aspects, such as the number of stations they plan to open.*
    - We will have three stations: Chino, CA; Rosemead, CA; and Selfridge Mi
    - We will also report from 2 non DOE stations: Oakland, CA & Orlando FL

Back-up Slides

Project Status

- Vehicle Tests
  - ➢ Performed Basic vehicle performance & functional tests in Korea
    - ✓ Wind tunnel, Hot chamber, NVH, coast down, Electrical reliability etc.
  - ➢ Performed preliminary baseline tests on V1 and V2
    - ✓ fuel economy , dynamic performance
  - ➢ Conducted environmental road tests w/UTC
    - ✓ Hot test (Aug. '05 @Death Valley)
    - ✓ High Altitude test (Oct. '05 @ Colorado)
  - ➢ Dyno baseline test conducted with V3 (DOE attendance Dec. 12~14 @Quantum)

- Data Collection
  - ➢ Data management system has been completed and is operating.
  - ➢ Real time monitoring system has been implemented for fleet vehicles.
  - ➢ On road data has been submitted to NREL monthly.

Challenges & Barriers to Deployment of FCVs

- Prolonged period of contract negotiation
- Unique fleet equipment requirements for AC Transit

Current AC Transit Supervisor Equipment Layout

Tucson Vehicle Equipment Layout

Challenges to Deployment of Hydrogen Infrastructure

- In order to gain a fact and experiential based benchmark of station costs by end of program:
    - Codes and Standards (including hydrogen purity) must evolve sufficiently and reasonably over the next 2 years.
    - Vehicle demand must sufficiently increase to allow full utilization of installed hydrogen capacity over the next two years.
- Driving Range
    - Vehicle design needs to advance over the next 2 years in order that station owners can determine how to assist in the driving range challenge

Progress Towards DOE Goals

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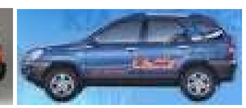
Stage	Technology Verification [~ '06]	Demonstration ['07 ~ '09]	Early Fleet Market ['10 ~]
Technology	Advanced Technology	Production Technology	Fleet Production

Cost Competitiveness & Durability

'10
Ready for Fleet Production

'08
Worldwide Fleet Operations

'04 ~ '09
US DOE Fleet Program (32 Vehicles)
Tucson FCV / Sportage FCV



'02
Santa Fe Fuel Cell Hybrid Vehicle

'00
California Fuel Cell Partnership
Santa Fe Fuel Cell Vehicle

California
Fuel Cell Partnership
Driving for the Future

1st Fuel Cell Vehicle
Sportage FCV

Supplemental Slide